ADHESIVELY BONDED VALVE COVER CYLINDER HEAD ASSEMBLY

Cross-Reference to Related Application

This application claims the benefit of U.S. Provisional Application No. 60/262,570 filed on January 18, 2001.

Background of the Invention

This invention relates to valve cover assemblies for internal combustion engines wherein the valve cover is bonded to the cylinder head by an adhesive. The invention also relates to a valve cover for use in such an assembly having a cure-on-demand adhesive bonded thereon. The invention also relates to processes for bonding valve covers to cylinder heads of internal combustion engines.

Automobile and truck engines typically have their valve train components covered with covers designed to protect the valves and internal components from a variety of external contaminants and to contain engine oil and combustion gases within the engine for proper disposal. These covers are variously referred to as valve covers, rocker covers, cam covers and the like. Traditionally these valve covers have been made from metal materials such as steel, magnesium, or aluminum. Recently, in order to reduce cost and weight, valve covers have been made from thermoset plastic materials or thermoplastic materials which can withstand the high underhood temperature environment, see for example, US Patent 5,492,086 US Patent 5,375,569, US Patent 5,746,168 and US Patent 5,363,759. Typically the valve covers are attached to the engine by bolting the valve cover to the cylinder head. In order to seal the internal engine components from the outside environment and contain engine oil and combustion gases a gasket is disposed between the valve cover and the cylinder head.

It is well known that some plastic materials creep when exposed to hot temperatures and pressure. This causes concern with the use of thermoplastic materials as valve covers especially, when the thermoplastic based valve covers are tightly bolted in place. Typically, the mechanical fasteners used compress the valve cover and gasket and can contribute to this creep. U.S. Patent 5,365,901 discloses a means for solving this problem. The patent discloses the use of a low creep material as a flange that is bolted to

the cylinder head wherein the valve cover is mechanically or chemically locked to the flange.

The problem with traditional valve covers is that assembly of a valve cover to an engine is labor intensive and requires costly mechanical fixing devices, such as bolts and threaded bolt holes. The need to use threaded bolt holes also requires significant machining and cost. In addition, the traditional means of assembly requires the use of a gasket to seal between the valve cover and the cylinder head. This too requires significant labor. Further, gaskets tend to creep and crack with age resulting in leaks which impact engine performance and require costly repairs.

What is needed is a valve cover that can be affixed to an engine without the need for gaskets and costly mechanical fixation means, such as bolts and threaded bolt holes. What is further needed is an engine assembly which has a valve cover affixed to the cylinder head of the engine wherein the valve cover is affixed without the need for gaskets and costly mechanical fixation means. What is also needed is a method for affixing a valve cover to the cylinder head of an engine without the need for gaskets and costly mechanical fixation means. As used herein costly mechanical fixation means refers to mechanical means of attaching a valve cover to a cylinder head that requires expensive parts, a significant amount of labor, costly machining or a combination thereof.

Summary of the Invention

The invention is a valve cover assembly comprising a valve cover wherein the valve cover has a mating surface adapted to be attached to a cylinder head of an internal combustion engine having a continuous bead of adhesive disposed on the perimeter of the mating surface. Preferably the valve cover does not have bolt holes adapted to serve the primary function of holding the valve cover in place. Preferably, the adhesive is a cure-on-demand adhesive adapted to hold the valve cover in place.

In another embodiment the invention is an engine assembly comprising one or more valve covers which preferably do not have bolt holes adapted to hold the one or more valve covers in place, wherein each valve cover has a mating surface and one or more cylinder heads wherein each cylinder head has mating surfaces adapted to fit to the mating surfaces of the valve covers wherein each valve cover is adhesively bonded to a cylinder

head along such mating surfaces. A continuous layer of adhesive is disposed between the mating surfaces of each valve cover and the cylinder head to which each valve cover is bonded. The continuous layer of adhesive forms a seal between the mating surface of each valve cover and cylinder head.

In yet another embodiment the invention is a method for bonding a valve cover to a cylinder head comprising

a) applying to either of a cylinder head or a valve cover, wherein the valve cover and the cylinder head each have mating surfaces adapted to be mated, a continuous bead of adhesive on the mating surface of the cylinder head or the valve cover;

b) contacting the mating surface of the valve cover with the mating surface of the cylinder head such the continuous bead of adhesive is disposed between the mating surfaces of the valve cover and the cylinder head;

c) curing the adhesive to form a permanent bond between the mating surfaces of the valve cover and the cylinder head wherein the adhesive forms a seal between the valve cover and the cylinder head.

The inventions provide means of assembling a valve cover to an engine without the need for expensive mechanical attachment means the need for a gasket and or the need to specially prepare the mating surface of either the valve cover or the cylinder head. The invention allows assembly of an engine with a significant reduction in the amount of labor needed to assemble the engine. Further, the invention allows assembly of an engine without the need to exert compression on either the gasket or the valve cover to hold it in place.

Summary of Figures

Figure 1 shows an exploded view of a conventional valve cover cylinder head assembly.

Figure 2 shows an exploded view of a valve cover cylinder head assembly of the invention.

Figure 3 shows a cut away view exploded view of a valve cover and cylinder head assembly.

Figure 4 shows an unexploded cut away view of the valve cover cylinder head assembly.

Figure 5 illustrates a valve cover having ports.

Figure 6 illustrates a cut away view of a sealing lid for the ports of the valve cover of Figure 5.

Figure 7 illustrates another method of attaching a sealing lid for the port to the valve cover illustrated in Figure 5.

Figure 8 shows a two-part valve cover.

Figure 9 shows an exploded view of the two-part valve cover and the engine head.

Figure 10 shows the two-part valve cover attached to the cylinder head using an adhesive.

Detailed Description of Invention

As used herein the term valve cover includes the following terms: valve covers, cam covers, rocker covers and cylinder head covers. A valve cover refers to the cover, which is placed over a cylinder head to protect be cylinders and internal engine components from damage due to exposure to outside elements and to contain engine oil and exhaust gases in the engine. The valve covers that are useful in this invention can be of any shape or size that performs the desired function. The valve cover can be made from any conventional material commonly used for valve covers, for instance a metal, a plastic or a plastic based composite. Preferred metals include steel, aluminum and magnesium. Plastic based materials can be thermoset plastics and thermoplastic materials. The plastic based materials can be reinforced with common reinforcement materials such as glass fibers and the like. Among useful thermoset materials are those based on epoxy, polyester, divinylbenzenes, and dicyclopentadiene resins. Among preferred thermoplastic materials are polybutylene terephthalate, polyetherimides, polyphenylene ether/polyamide resins, polyether sulfone resins, polyether ether ketone resins, liquid crystal polymers, polyarylsulfone resins, polyamideimide resins, polyphthalimide resins, nylon 6, 6 and nylon 6 polyamide resins, polypropylene, syndiotactic polystyrene, and blends thereof. Preferably, the thermoplastic material is a blend of nylon 6, 6 or nylon 6 with syndiotactic polystyrene. Such as disclosed in commonly assigned U.S. Patent Application No. 60/263,954, filed January 24, 2001, titled *Toughened Polymer Blends With Improved*

Properties, incorporated herein by reference. Common additives such as glass fibers, minerals, impact modifiers and the like may be included in the resins. From a balance of properties and cost performance standpoint the preferred thermoplastic resins are nylon 6, 6 and nylon 6 polyamide resins, syndiotactic polystyrene and blends thereof. Of classes of materials useful in fabricating valve covers, plastic materials are preferred because plastic materials are generally lighter than metals and provide greater design flexibility over metals.

The valve covers are bonded to the cylinder head using an adhesive composition. Any adhesive that after cure can withstand the conditions of use of an automobile engine can be used. Preferably such adhesive does not decompose or delaminate at temperatures of up to about 280 °F (138°C), more preferably up to about 290 °F (143°C), even more preferably up to about 320 °F (160°C) and most preferably up to about 375 °F (191°C).

~~Furthermore, the adhesive must be able to withstand exposure to~~ hydrocarbon materials, engine oil, calcium chloride, brake fluid, glycol coolants, windshield washer solvents and the like, at the above-mentioned temperatures and the pressures to which the internal combustion engine reaches internally. The adhesive must be able to bond to the material used to make the valve cover and to the material from which cylinder heads are prepared, such as, cast iron, aluminum and magnesium. The adhesive used is a structural adhesive which is an adhesive which has sufficient cohesive strength to hold the valve cover in place during normal operating conditions. Preferably, the cohesive strength measured in Lap Shear mode according to ASTM D3165-91 or in tensile mode according to ASTM D638 Type 4 is 250 psi (1724 kPa) or greater, more preferably 500 (3447 kPa) or greater and most preferably 1000 psi (6895 kPa) or greater. The adhesive used can be cured via a variety of known mechanisms including heat cure, infrared cure, ultraviolet cure, chemical cure, solvent loss and moisture cure. In another embodiment the adhesive can be a cure-on-demand adhesive which requires a separate operation to cause the adhesive to begin to cure. In one embodiment this is achieved by using an encapsulated curing agent which needs to be ruptured. In another embodiment this is achieved by removing a protective coating to expose the adhesive to ambient conditions. Cure can be initiated by exposing the adhesive to heat, infrared or ultraviolet light sources, or to shearing forces and the like. ~~Preferably the adhesive is a high temperature epoxy resin, a polyimide, a hi-bred~~

polyimide/epoxy resin adhesive, a silicone, a fluorosilicone, an alkylborane initiated acrylic adhesive system, or an epoxy novolac/nitrile rubber adhesive High temperature adhesive means an adhesive which when cured can withstand exposure to the temperatures mentioned above without decomposing or delaminating from the substrate.

The valve cover can be designed in any manner that is suitable to perform its function. A valve cover useful in the invention has a mating surface that is adapted to be mated with a mating surface of a cylinder head such that the two mating surfaces can form a tight seal therebetween with the aid of the adhesive. Any suitable design of the mating surfaces can be used. For instance the two mating surfaces may be flat all along the surfaces to be mated, they may form a lap joint, a scarf joint or a tongue in groove joint or the like.

In one embodiment the invention is a valve cover having disposed on the its mating the surface a continuous bead or film of adhesive. As used herein continuous bead or film of adhesive means a bead or film of adhesive that is disposed around the periphery of the mating surface and the end of the adhesive bead or film connects with the beginning of the adhesive bead or film. The continuous bead or film of adhesive upon cure is capable of forming an air and liquid tight seal between the valve cover and cylinder head. This function allows the adhesive bead or film to replace gaskets as the sealing means between valve covers and cylinder heads. The adhesive may be applied to the valve cover in the immediate vicinity of the location where the valve cover is to be contacted with the cylinder head or it may be applied in a location remote from the place where are the valve cover and a cylinder head are to be contacted. Remote as used herein refers to one or both of time and location. In the embodiment where the adhesive is applied to the valve cover remote from the place wherein the valve cover is contacted with the cylinder head a cure-on-demand adhesive must be used.

In one embodiment the valve cover can contain an integral mechanical fastening means which is adapted to hold the valve cover in place on the cylinder head until the adhesive cures. Such integral mechanical fastening means as used herein means a simple means to hold the valve cover and cylinder head together for a relatively short period of time while the adhesive cures. Such mean is not designed to hold the parts together during operation of an engine. By integral is meant that the fastening means is part of the

valve cover, cylinder head or both. Examples of such fastening means include integral spring clips, snap fit mechanisms, screws, bolts and the like. Such fastening means can be strategically located along the valve cover and the cylinder head interface or can be located along the entire cylinder head valve cover interface. In a preferred embodiment the mechanical fastening means is a snap fit means. Preferably the mechanical fastening means is located on the inside portion of the valve cover and cylinder head, wherein inside portion refers to the inside of the engine and valve cover. This is preferred because the fastening means cannot be seen from the exterior of the engine. In another embodiment the valve cover may have protruding from its mating surface a leg or protrusion adapted to guide the valve cover or hold the valve cover along its mating surface in proper relationship to the cylinder head. In some embodiments, the cylinder head may have a matching indentation or groove adapted to work with the leg or protrusion to aid in holding the valve cover and cylinder head in proper alignment. In another embodiment, one or more bolts and bolt holes can be included in the valve cover for a purpose other than attachment purposes, such as alignment purposes or for attaching other items to the valve cover. In some embodiments such a bolt or screw can have a matching female threaded receptacle in the cylinder head. The primary function of such bolts or screws is to attach peripheral items to the valve cover. In some embodiments valve covers have gaskets mounted on ports in the valve cover designed to seal about the port. In some of these embodiments the port is used to insert a peripheral item into the valve cover area, such as a spark plug or coil. As access is needed to repair or replace the peripheral component a gasket is used because a gasket is easier to remove and place than a cured adhesive seal. A bolt or screw can be used to hold the peripheral item in place in the port. Such a bolt or screw can provide compression on the gasket which seals the port on the valve cover.

In another embodiment the invention is an engine assembly wherein the valve cover as described herein is bonded to a cylinder head with the adhesives disposed between the valve cover and the cylinder head. The adhesive is in the form of a continuous bead or film such that it forms a seal along the entire juncture between the valve cover and cylinder head. Such engine assembly by virtue of the use of adhesive bonding and plastic valve covers enable the use of the valve cover in a multi-functional way such that other parts and functions can be incorporated into the valve cover and the engine assembly.

The valve cover of the invention may further comprise one or more ports to allow access to the cylinder head. A port is an opening in the valve cover that provides for the access. To function properly each port must have a means for covering and sealing the access ports. In a preferred embodiment ports are covered with a cover that seals the valve cover to prevent or significantly reduce the transmission of gas and liquids through the valve cover during operation of the engine. Significantly, reduced transmission means that the majority of the gasses and liquids that would be transmitted, if no seal is present, would not be transmitted. The port can be any shape or size to meet the needs of providing access on demand and allowing sealing of the valve cover during operation. The port can comprise the entire top of the valve cover wherein the cover of the port is the top of the valve cover. In this embodiment the top is attached to the rest of the valve cover using any means which allows formation of a seal between the cover and the rest of the valve cover. In one embodiment the port or cover has a male ridge about the perimeter of the port or the cover and the other of the cover or the port has a female groove which matches the ridge and which forms a seal when the ridge is united with the groove. The male ridge and female grooves can contain a means for locking or holding the ridge in the groove so as to insure sealing. In another embodiment the one or more ports can be smaller and the cover can be any kind of cover that seals the port as desired. In one embodiment the valve cover can have a port for each cylinder. The cover can comprise the female portion of a screw on cap with matching threads on the port having a male receptacle for the screw on cap. The cap can also be attached in a sealing manner to the port by any means of attachment, such as a device which has a protrusion on the port which matches the cover and which allows the cover with matching grooves to be attached to the port by twisting and locking the groove in the protrusion. In the event of a screw style cap or twist on locking cap the port preferably protrudes from the valve cover to facilitate attachment of the cover, for instance in the form of a male screw top or locking device. Alternatively the valve cover can contain one or more recessed areas having female threads that the cover screws into.

The cover on the port of the valve cover or the valve cover can also incorporate other functional devices that can work with the engine. Any device which can be located on a valve cover and perform its' necessary function can be located on the valve cover or cover of a port. Examples of devices which may be incorporated into the valve

cover or port cover include coils, pcv (positive crankcase ventilation), systems, fuel rails, fuel injectors and the like. In the case of coils, pcv systems and fuel injectors it is preferable that there be a port and associated device or an associated device attached to the valve cover for each cylinder. The port cover can be made of any material that can handle the conditions to which the valve cover is exposed. Preferably the valve cover and the port cover are made of the same material.

In preparation of the engine assembly, the adhesive is applied to the valve cover or the cylinder head by contacting the adhesive in a conventional fashion with the mating surface to form a continuous bead or film. The adhesive may be coated, extruded brushed or the like, onto the surface. Preferably the adhesive is applied to the mating surface of the valve cover. In a preferred embodiment the adhesive is applied as a continuous bead or film along the mating surface of the valve cover. The adhesive can be applied immediately before contacting the valve cover with the cylinder head or it can be applied in remote location from the location where the valve cover is bonded to the cylinder head or at an earlier time with respect to the bonding operation. In the embodiment where the adhesive is applied just prior to contacting the valve cover and the cylinder head, any adhesive which meets the performance criteria defined above may be used. In the embodiment where the adhesive is applied in a remote location or at a remote time, an appropriate cure-on-demand adhesive may be used. The cure-on-demand adhesive is exposed to conditions such that it will cure and thereby bond the valve cover to the cylinder head and form a seal between them. Such conditions can be applied prior to contacting the cylinder head with the valve cover or after such contacting. It is well within the average level of skill in the art to determine which operation may be used to cure the adhesive and when it should be performed. In one embodiment the operation may be an operation that is inherent in the assembly of an automobile or in the running of an automobile.

In another embodiment the valve cover may include an integrated acoustic management system designed to prevent the noise inherent in the operation of an internal combustion engine from escaping the engine compartment. In one embodiment the valve cover can comprise two parts one being an outer shell and the other being an inner shell adapted such that the inner shall is located within the outer shell such that there is a gap between the two. The gap may simply contain air which can attenuate certain sound waves

thereby reducing the noise that can be heard outside the engine. Alternatively the gap can be filled with a sound deadening material such as shoddy pad, nonwoven mat, elastomeric material or foam material. In another embodiment the valve cover may have bound to its inner surface a sound attenuating material such as the elastomer or foam.

In another embodiment the valve cover of the invention can comprise a coating or film on the exterior or interior which functions to improve the barrier properties of the valve cover to hydrocarbons. Such a coating of film can reduce the fugitive hydrocarbon emission from an automobile. Any coating or film which prevents the transmission of hydrocarbons through the valve cover may be used. A preferred coating is a carbon-silica based plasma deposited coating as described in U.S. Patent 5,298,587; U.S. Patent 5,320,875; U.S. Patent 5,433,786 and U.S. Patent 5,494,712 incorporated herein by reference.

To illustrate the invention the figures are described below. The figures are provided to aid in illustrating the invention and are not intended to limit the scope of the claims hereinafter. Figure 1 shows an exploded view of a conventional valve cover cylinder head assembly. The figure shows three main parts, a cylinder head (10), a gasket (11), and a valve cover (12). Figure 1 shows that the gasket (11) is disposed between the valve cover (12) and the cylinder head (10). The cylinder head (10) has a plurality of machined bolt holes (13) adapted for receiving a plurality of bolts (14) in a manner such that the bolts (14) and bolt holes (13) in the cylinder head (10) secure the valve cover (12) in place with the gasket (11) disposed between them. The machined bolt holes (13) have machined threads to hold the bolts (14) in place. The valve cover (12) and the gasket (11) have a plurality of bolt holes, (17 and 18 respectively), which line up with the machined bolt holes (13) of the cylinder head (10). The bolts (14) go through spacers (15) and washers (16) before going through bolt holes (17) and (18) of the valve cover (12), and the gasket (11) and screw into the threaded machined bolt holes (13) of the cylinder head (10). As can be seen from this figure, a large number of bolts (14) are needed to affix this valve cover (12) onto the cylinder head (10). The bolts (14) function to compress the gasket (11) to enhance the seal. The assembly of the cylinder head (10) and the valve cover (12) requires significant machining and labor.

Figure 2 shows and exploded view of a valve cover cylinder head assembly. The figure shows a cylinder head (20) and a valve cover (21) having a continuous bead of adhesive (22) located between them. The valve cover (21) has integral snap fit clips (23) adapted to hold the valve cover (21) in place on the cylinderhead (20) while the adhesive bead (22) cures. The cylinder head (20) has matching indentations (24) which match with the snap fit clips (23) which receive the clips (23) and function to hold the valve cover (21) in place. Also visible in the figure is the mating surface of the cylinder head (25) adapted to mate with the corresponding mating surface of the valve cover (not shown).

Figure 3 shows a cut away view exploded view of a valve cover (21) and cylinder head (20) assembly. The exploded view shows the cut away of a cylinder head (20) a valve cover (21) and located therebetween is an adhesive bead (22). The adhesive bead (22) is located between the mating surface of the cylinder head (25) and the mating surface of the valve cover (26). The cylinder head (20) has an indentation (24) adapted to mate with the snap fit clips (23) of the valve cover (21).

Figure 4 shows an unexploded cut away view of the valve cover (21) cylinder head (20) assembly. Shown is a cylinder head (20) with a valve cover (21) adhesively bound together by a continuous bead of adhesive (22) along the mating surface of the cylinder head (25) and the mating surface of the valve cover (26). Also shown is a snap fit clip (23) integrated with the valve cover (21) and engaged with the cylinder head (20) by the indentation (24) adapted to hold the snap fit clip (23) in place. The snap fit clips (23) are located in the inside of the valve cover (20) and cylinder head (20) assembly. This is desirable for cosmetic reasons.

Figure 5 illustrates a valve cover (30) having ports (31) with raised lips (32), which raised lips are designed to work with sealing lids (33) to seal the valve cover. Figure 6 illustrates a cut away view of the raised lip (32) and corresponding sealing lid (33). Also shown is the port (31). Figure 6 shows a snap fit seal which has a female indentation (34) on the outside of the lip (32) which is adapted for receiving a male protrusion (35) on the sealing lid (33). The indentation (34) and the protrusion (35) are located around the entire circumference of the lip (32) and the sealing lid and fit together to form a seal between the lip (32) and the sealing cap (33), so as to seal the interior of the valve cover (30) from the

exterior. Figure 7 illustrates another method of attaching the sealing lid (33) to the valve cover (30). The lip (32) has a female screw line (37) that is adapted to receive the male screw line (36) of the sealing cap (33). Screwing the sealing lid (33) on the lip (32) allows for sealing the port (31) of the valve cover (30) from the exterior.

Figure 8 shows a two part valve cover (40) where the upper portion (41) can be separated from the lower portion (42) to allow access to enclosed engine parts. Figure 9 shows an exploded view of the two piece valve cover (40) and the engine head (43). Shown is the upper portion (41) of the valve cover (40) having a female opening (45) which is located about the entire perimeter of the upper portion (41) of the valve cover (40) and adapted to receive the male protrusion (44) of the lower portion (42) of the valve cover (40). The male protrusion (44) extends about the perimeter of the lower portion (42) of the valve cover (40). The female opening (45) has indentations (46) perpendicular to the indentation of the female opening (45) adapted to receive perpendicular protrusions (47) on the male protrusion (44) of the lower portion of the valve cover (42). The perpendicular protrusions (47) are perpendicular to the direction of the male protrusion (44). The indentations (46) and the perpendicular protrusions (47) serve to lock the upper portion (41) of the valve cover (40) to the lower portion (42) of the valve cover (40). Also illustrated is the area where adhesive is to be applied (47). Figure 10 shows the two-part valve cover (40) attached to the engine head (43) using an adhesive (49). Figure 10 also shows the upper portion (41) and the lower portion (42) of the valve cover (40) assembled wherein the male protrusion (44) of the lower portion (42) is located within the female opening (45) of the upper portion (41) and locked by the perpendicular protrusions (47) of the male protrusion (44) being located in the indentations (46) of the female opening (45).